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A PROGRESS REPORT ON THE CHIPPING QUALITY OF 33 POTATO VARIETIES[1]

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INTRODUCTION

Varieties of potatoes vary considerably as to their suitability for the commercial manufacture of potato chips. However, comparatively little study has been made of the performance of different varieties, or effort made to breed varieties more suitable for this purpose than those now available. The potato chip industry is of growing importance; it used about 20 million bushels for chip making, the past season. Potato chippers experience a great deal of difficulty in obtaining suitable raw

[1]Report of a study made under the Research and Marketing Act of 1946.
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stock, especially during late winter and spring or after potatoes have been in storage a few weeks after digging. The many inquiries addressed to this Department have prompted an investigation of the suitability of different varieties from different localities, and of different methods of storing and handling potato stocks for chipping purposes.

Acceptable chips can be made from almost any variety of potato during the first few days after harvest; but after a few weeks of storage even at a favorable temperature certain varieties undergo changes that cause them to develop an undesirable brown color when made into chips, although they may be entirely suitable for table use. Some varieties remain useful for chipping as long as they are kept at a temperature of approximately 50° F. or slightly higher; but they lose their usefulness if stored at temperatures much below this, and it is difficult or impossible to restore them to their original usefulness.

Potato storage houses in the North seldom remain as warm as 50° for very long after harvest. Probably in most areas where potatoes are stored extensively the storage house temperature reaches at least 40° to 45° by the end of October, with a range of 35° to 40° thereafter until spring. Certain other varieties are not especially "temperamental" or sensitive to cold. These do not readily get out of condition, but recondition readily when stored at about 70° to 80° for one or more weeks. The latter group of potatoes is most useful to the chipper because of its dependability for making a desirable product, especially late in the season when the other varieties cannot be used.

Experimental

This report covers two seasons' work with 33 varieties of potatoes obtained through the cooperation of the Potato Section of this Bureau. These included some older standard commercial varieties, several new varieties, and a few unnamed seedlings. All were grown at Presque Isle, Maine, on the same general type of soil, thus affording an opportunity for direct comparison of varieties grown under the same climatic conditions. Shortly after harvest they were shipped to the Beltsville laboratory where the lots were divided, and part of each was stored at 55° F. and part at 40°. Chips were prepared from the 55° storage lots after approximately 2 months. After about 3 months those stored at 40° were moved to 70° for 22 days and then made into chips. A uniform procedure was followed when cooking all lots. Ten representative tubers from each lot were sliced into uniform slices approximately 3/64 of an inch in thickness. A few slices from each

tuber were selected to make up a composite sample of 200 grams which was rinsed to remove excess starch, blotted between towels and then cooked in peanut oil at 340° until all water was expelled as indicated by cessation of bubbling. At the finish the oil temperature was 320°.

Salability based on the color of chips from 33 varieties of Maine-grown potatoes after storage at 55° F. and after conditioning at 70° for 22 days following storage at 40°.

Variety	Salable; from 55° Storage[1]	Not Salable; from 55° Storage	Conditioned Satisfactorily 40-70°	Conditioned unsatisfactorily 40-70°
Calrose	X		X	
Cayuga	X		X	
Chippewa	XX		XX	
Earlaine	X		X	
Earlaine 2		X		X
Erie	X			X
Green Mountain		X		X
Houma	X			X
Irish Cobbler	X		X	
Kasota	X		X	
Katahdin	X		X	
Kennebec	XX		XX	
Menominee		X		X
Mesaba	X			X
Mohawk		X		X
Netted Gem	XX		XX	
Norkota	XX		XX	
Pawnee	X		X	
Pontiac		X		X
Potomac		X	X	
Red Warda		X		X
Russet Rural	XX		XX	
Rural New Yorker	XX		XX	
Sebago	XX		XX	
Sequoia		X		X
Teton	XX		XX	
Triumph		X		X
Warba		X		X
White Rose		X		X
B61-3	X			X
B69-16	X			X
47258	X		X	
24642		X		X

[1] X Signifies acceptability.
XX Signifies outstanding attractiveness.

The results of two seasons' study are combined in the accompanying table. In the first column are shown the varieties from 55° F. storage which produced chips that were rated salable or better. This

group includes those that just make the salable grade—the chips being somewhat dark brown but usable, especially if mixed with lighter colored stock—and those that were of outstanding attractiveness, being of a uniform light golden color. Those of less attractiveness are indicated by X and those of greater attractiveness by XX. In the second column are shown those varieties the chips of which did not rate as salable. In the third column are given the varieties that could be successfully conditioned at 70° after being transferred from 40°. The chips made from these are rated as having greater or less attractiveness, as in column one. In the last column those varieties that could not be satisfactorily conditioned are indicated.

Summary

Thirty-three Maine-grown varieties of potatoes were studied to determine their comparative suitability for use in chip-making. In this study the varieties that proved to be unsuitable for chip-making, since they did not make a salable product even when stored at 55° F. or could not be satisfactorily conditioned (desugared) at 70° following storage at 40°, were Earlaine 2, Green Mountain, Menominee, Mohawk, Pontiac, Potomac, Red Warba, Sequoia, Triumph, Warba, White Rose, and Seedling 24642.

Varieties from 55° F. storage that produced chips of salable grade but not considered of outstanding attractiveness were: Calrose, Cayuga, Earlaine, Erie, Houma, Irish Cobbler, Kasota, Katahdin, Mesaba, and Pawnee. These varieties also produced chips of salable but not outstanding grade when conditioned, with the exception that Erie, Houma, and Mesaba could not be satisfactorily conditioned after storage at 40°.[1]

Varieties that produced chips of outstanding attractiveness after storage at 55° F. and after conditioning at 70° following storage at 40° were: Chippewa, Kennebec, Netted Gem (Idaho Russet), Norkota, Russet Rural, Rural New Yorker (Smooth Rural), Sebago, and Teton.

POTATO STORAGE: EFFECT ON THE PASTE VISCOSITY OF THE STARCH

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When potato starch is heated in water the starch granules swell enormously, forming a paste. The viscosity of even 1 per cent potato starch paste may be several hundred times that of the water. To a large extent the industrial usefulness of potato starch depends on the viscosity of its pastes. High viscosity is usually associated with starch of good quality, and is taken as an indication that chemical, bacterial, and thermal deterioration of the starch during manufacture and storage has been avoided. Potato starch is sensitive to seemingly trivial changes in composition and environment, and its pasting properties sometimes greatly change simply on keeping the air-dry starch at room temperature for a few days or weeks (7).

Normal operation of a potato starch factory extends for several months beyond the harvest season. During this time the stored potatoes may lose a substantial part of their original starch. As the first step, the starch is presumably reduced to a soluble form, sugars. Then these are oxidized to carbon dioxide and water, the extent depending on the temperature, and eliminated by the ordinary process of respiration. At temperatures near the freezing point, the oxidation is relatively slow, with the result that sugars accumulate in the potato at the expense of its starch. If subsequently kept for a week or two near room temperature, much of the sugar is reconstituted into starch by the same enzymes in the potato that synthesized the starch while the potato was growing on the vine. It might reasonably be expected that the partial destruction and partial resynthesis would change the growth structure of the granules sufficiently to alter the properties of the paste and thus the quality of the starch. That this occurs has been implied by Katz (2), but no experimental test was reported.

The present paper reports on the paste viscosity of starch extracted from Green Mountain potatoes grown at Aroostook Farm, Presque Isle, Maine, and stored there at 34°, 42° and 50° F. for periods up to nine months. Changes in the starch and sugars contents of the same lots of potatoes have been determined by Treadway, Walsh, and Osborne (5).

[1]One of the laboratories of the Bureau of Agricultural and Industrial Chemistry, Agricultural Research Administration, United States Department of Agriculture.

Materials and Methods

Five-pound samples of potatoes were taken from storage at approximately seven-week intervals. A period of seven to ten days, during which the temperature was 60°-70° F., then elapsed before the starch was extracted. The potatoes were peeled manually, with an average loss in weight of 13 per cent. They were chopped and passed twice through a hammer mill, and the pulp was diluted and screened through 40- and 80-mesh sieves. The starch was tabled twice, passed through a 150-mesh screen, settled, and dried at 70° F. to a moisture content of 10 to 12 per cent. All water added was distilled water, and no sulfur dioxide or other preservative or bleaching agent was used.

The viscosity of 3.5 per cent pastes in distilled water was measured at 192° F. for periods varying to three hours. The pastes were stirred at 10 r.p.m. with a broad, slotted paddle to maintain a uniform temperature, and thus consistency, throughout the one-liter volume of paste. Measurements were made with a Brookfield viscosimeter; rotors 3 and 4 and a rotor speed of 30 r.p.m. were used. Reproductibility of data was usually better than 5 per cent, and often better than 1 per cent. The viscosity data indicate apparent viscosity only. They are reported in poises as computed from the instrument readings.

Results

Starch Recovery. The yield of moisture-free starch ranged from 12.2 to 14.7 per cent of the weight of the pared potatoes. The proportion of starch recovered to the total amount, as measured by Treadway, Walsh, and Osborne (5), varied from 78 to 86 per cent. Essentially no change in the efficiency of extraction was associated with either the temperature or duration of storage. Starch was as fully recoverable from the excessively sprouted and withered potatoes stored at 50° F. as from sound potatoes stored at 34° F. The smaller quantities of starch recovered from the latter samples (averaging 12.4 per cent) in comparison with that recovered from potatoes stored at 42° and 50° F. (averaging 13.6 and 13.8 per cent) were related to the lower starch content (5).

Analytical Data; Whiteness. Analysis of a typical starch showed the following: nitrogen, 0.01 per cent; fat, 0.03 per cent; ash, 0.22 per cent; calcium, 0.0037 per cent; and phosphorus, 0.071 per cent. Only in whiteness were the laboratory starches inferior to an excellent grade of commercial starch. The difference is expressed by the diffuse reflectance for blue light (wave length 4500 angstrom units) compared

with magnesium oxide: commercial potato starch, 91 per cent; typical laboratory starch, prepared without sulfur dioxide, 83 per cent.

Viscosity. Starch paste viscosity arises principally in the resistance to flow offered by the swollen starch granules. Potato starch granules swell to an extraordinary extent, with the inevitable result that the boundary membranes or envelopes are extremely thin. The granules are then easily disrupted by solution of the starch membrane in hot water, or mechanically, by stirring or other motion of the paste. By such processes, the average bulk of the swollen granules continuously decreases, and correspondingly the viscosity falls. In the present experiments the viscosity decrease amounted to approximately 50 per cent in two hours at 192° F.

In table 1 the viscosity of 3.5 per cent pastes at a pasting time of 60 minutes is compared. The data show that starch quality, as indicated by viscosity, is not lowered by prolonged storage of the potatoes. Viscosity differences are most pronounced in starch prepared from potatoes stored at 34°, and the viscosity shows fluctuations rather than

TABLE 1—*Viscosity of starch from stored potatoes*

[Measurements made on 3.5 per cent pastes in distilled water at 192° F; 60 minutes pasting time. Viscosity for starch extracted from potatoes at beginning of storage period, 46 poises.]

Temperature of Storage, °F.	Viscosity of Starch from Potatoes Stored for (Weeks)				
	7	13	22	29	37
	Poises	Poises	Poises	Poises	Poises
34	34	54	61 (13)[1]	50	72
42	66	66	67	68	71
50	55	73	69	64 (13)[1]	69

[1]Pastes made with tap water.

a trend. Starch from potatoes stored at 42° and 50° is of substantially equal quality. With two outstanding exceptions, the variation in viscosity in the whole group of starches is relatable to the pH and calcium content. The range of pH was 5.64 to 6.52, and the range of calcium content, 0.0028 to 0.0059 per cent. The viscosity values in table 1 are, roughly, in direct proportion to starch pH and in inverse proportion to the percentage of calcium. Thus an increase of one pH unit raised the viscosity about 28 poises, and an increase of 0.001 per cent in calcium diminished the viscosity by about 8 poises. This leads to the expectation that the starches, if made equal in pH and content of calcium, would

show equal viscosity also. The two starches with lowest paste viscosity, 34 and 46 poises, were the first to be extracted, and were obtained respectively from potatoes stored seven weeks at 34° and from the original or non-stored potatoes. Both starches had a somewhat musty odor. The subnormal viscosity is possibly due to microbial spoilage during the preparation, which kept these starches moist for an appreciably longer time than the starches subsequently prepared.

Effect of Water Quality on Viscosity. A notable feature of the data in table 1 is the decrease in viscosity from more than 60 to 13 poises caused by pasting with tap water rather than distilled water. This is doubtless an electrolyte effect, analogous to the pH and calcium effects already mentioned but of much greater extent. The predominant importance of electrolytes in determining the paste viscosity of potato starches is illustrated further in experiments with an excellent grade of commercial potato starch. The results are summarized in table 2.

TABLE 2—*Effect of water quality on the viscosity of high grade commercial potato starch*

[Measurements made on 3.5 per cent pastes after 60 minutes pasting at 192° F.]

Treatment	Viscosity
	Poises
Starch pasted with distilled water	18
Starch pasted with tap water	8
Starch washed four times with distilled water, then	
a. Pasted with distilled water	36
b. Pasted with tap water	10
c. Pasted with distilled water containing 50 p.p.m. calcium chloride.	13

These results show that the viscosity of the commercial starch pasted in distilled water was only one-third to one-fourth that of the normal laboratory starches. This low viscosity was reduced considerably further by pasting with tap water. Washing the starch with distilled water and then pasting with distilled water increased the viscosity to 36 poises, double the original viscosity. Pasting the washed starch with tap water reduced the viscosity to 10 poises; and pasting with water containing 50 p.p.m. calcium chloride resulted in a viscosity of 13 poises. The pH of the commercial starch was 6.50 before washing and 6.38 after washing; its respective calcium contents were 0.057 and 0.052 per cent. The distilled water wash, then, removed 0.005 per cent of calcium, equivalent to about one-tenth of the total amount present, and simultaneously raised the viscosity 18 poises.

Discussion

The potatoes used in this work lost approximately 30 per cent of their starch while in storage (5). This figure was obtained on potatoes immediately after withdrawal from cold storage. In the two-week interval before extraction of the starch, part of the sugar had been reconstituted into starch and part eliminated by respiration. Our viscosity data imply that this change did not alter the granule structure or the starch molecules within it sufficiently to change the swelling capacity of the granules or to change the stability of the swollen granules toward dissolving, mechanical breakage, or loss in volume by diffusion into the pasting medium.

Sensitivity of potato starch paste viscosity to electrolytes has been noted previously (3, 4, 7). A quantitative explanation cannot yet be given. The electrolyte sensitivity is due to the small amount of phosphoric acid chemically combined with the starch molecules. The acidic properties of this starch-phosphoric acid closely resemble those of orthophosphoric acid, H_3PO_4 (1). This means that at pH about 6.5 the two ionizable hydrogens of starch-phosphoric acid are on the average three-fourths replaced by metal ions. In the potato and in starch extracted with pure water, the metal ion is principally potassium (6), but this is readily displaced by the calcium and magnesium ions contained in the surface or ground water ordinarily used by potato starch factories. Potassium starch ionizes when pasted, leaving a considerable negative electric charge on the granules. Calcium starch ionizes much less because calcium is bound tightly to the phosphoric acid groups. Correspondingly, the negative charge on the granules is less. It appears that the ability of potato starch granules to imbibe water and swell is determined largely by the charge. Reagents that decrease the charge decrease granule swelling and thus the viscosity of potato starch pastes. Much of the variability reported for potato starches may be ascribed to the neglect of small amounts of electrolytes.

It may be conjectured that seasonal changes in commercial potato starch quality such as indicated by Katz are actually more a reflection of seasonal changes in the amount or composition of the mineral content of the processing water than differences in the starch itself.

Summary

The quality of potato starch, as indicated by paste viscosity, was not affected by storage of the potatoes for periods up to nine months at temperatures of 34°, 42°, and 50° F. The composition of the water

used in extracting the starch is of considerably greater importance in determining starch quality.

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RING ROT OF POTATOES[1]

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Part I—Rate of spread of the organism and losses incurred by infection with *Corynebacterium sepedonicum* (Spieckermann and Kotthoff) Skaptason and Burkholder.

Ring rot of potatoes was definitely recognized in Idaho, during the growing season of 1939, in the early producing areas of the state. Observations indicated that this disease was present in the areas earlier and that importations of infected seed were responsible for its occurrence in such areas. The disease was something new to all parties concerned and was of much concern to producer, shipper, and investigator alike. A program of investigational work was therefore instituted. Among the matters investigated were such as effectiveness of various chemicals as seed disinfectants, and knife disinfestants; the use of a rotating disc seed cutting knife; a comparison of assist-feed planters *vs.* picker-type planters in disseminating the causal organism; the rate of increase of infection in a crop that was grown from seed with known amounts of infected seed pieces in it and the relation between percentage of disease in a crop and the resulting reduction in yields.

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[1]Published with the approval of the Director of the Idaho Agricultural Experimental Station as Research Paper No. 287.

[2]Associate Plant Pathologist.

This paper is to report on those phases of the program relating to the rate of increase of infection in a crop grown from seed with known amounts of infected seed pieces in it; the relative ability of picker and assist-feed types of planters in spreading the organism; and reduction in yields of marketable tubers, in crops with known amounts of disease in them. Bonde and Merriam (1) have shown how, with varying percentages of infected seed pieces in the original seed, the amount of disease will increase through a period of three years. Unlike the Maine tests, this paper deals with yearly increases in amount of disease.

Experimental Procedure

1. *Seed*

The planter test was conducted in 1943. Clean cut and single drop seed was used. Each treatment was replicated twice; each replication consisting of a row of approximately 100 plants. The planters were contaminated before planting by rubbing diseased tubers over the planting plates and platform of the assist-feed planter and jabbing the pickers of the picker planter with an infected tuber.

In 1944 and 1945, five lots of 100 Russet Burbank tubers, containing 1, 3, 5, 7, and 9 per cent of infected tubers respectively, were halved. Thus, each lot contained 200 seed pieces in which the percentage of infection was not altered. The tubers were cut with a non-sterilized rotating disc cutting knife. In each lot the first tuber to be cut was infected; in Lot II the 33rd and 66th were also infected. The tubers in the remaining lots were cut in a comparable manner according to the following plan:

Lot	Per cent of Tubers Infected	Order in Which Infected Tubers Were Cut
I	1	1
II	3	1-33-66
III	5	1-20-40-60-80
IV	7	1-14-28-42-56-70-84
V	9	1-11-22-33-44-55-66-77-88

The same general plan that was followed in 1944 and 1945 was again used in 1946, except that lots of seed containing 2 and 10 per cent infected tubers were also included. The seed for 1946 was cut in the following order:

Lot	Per cent of Tubers Infected	Order in Which Infected Tubers Were Cut
I	1	1
II	2	1-51
III	3	1-33-66
IV	5	1-21-41-61-81
V	7	1-14-28-42-56-70-84
VI	9	1-12-23-34-45-56-67-78-89
VII	10	1-11-21-31-41-51-61-71-81-91

Each year, the infected seed pieces were allowed to remain in the seed and were planted with the remainder of the seed of each respective lot. Planting was accomplished with an assist-feed planter. The planter was thoroughly disinfected between the planting of each lot. The seed for each treatment was planted in one row.

2. *Recording Results*

For the planter test, counts were made on three separate occasions during the season and on the day of each count, the diseased plants were eliminated. The stain test was not used in connection with this portion of the experiment.

In 1944, four 25 consecutive-hill units were staked off, at random, in each row, upon which data were collected. During the season the plants were examined twice and the plants of all hills showing aerial symptoms were eliminated and the numbers recorded. The remaining hills were dug by hand at harvest time and separately bagged for later examination.

In 1945 and 1946, five 10 consecutive-hill units were staked off, at random, in each row, upon which data were collected. At harvest time, each hill was separately dug by hand, and the tubers bagged for later examination.

The Grain-stain test was used in accordance with Racicot, Savile, and Conners (2) to ascertain the number of hills which were involved with ring rot. A separate smear was made for each No. 1 tuber of each hill. A composite smear was made of the culls of each hill. If a single smear of any of the progeny of a hill was gram positive, the hill was considered as being diseased. The weight of the disease-free No. 1 tubers, of each, was recorded.

3. *Losses*

Observations had shown that there is not always complete loss of the crop when a hill is involved with ring rot. If the attack is early in the development of the plant, it, in all probability, will be killed. In cases of late development of the disease, there will generally be some production of marketable tubers. It was determined, therefore, to correlate known percentages of disease in the crop with losses.

The 1944 and 1945 tests were so set up that by rearranging the data obtained, it was possible to secure categories of 0, 10, 20, 30, 40, 50, 60, 70, 80, 90, and 100 per cent disease. Yields of disease-free marketable tubers were recorded for each ten-hill replicate. It was therefore possible to compare the yields secured in the various categories, where there were known amounts of disease, with the yields secured in that category where there was no disease.

Results

1. *Rate of Spread*

The results obtained in the planter test conclusively showed the picker type of planter to be an efficient means in spreading the organism. In table 1 can be found data showing the relative ability of the two types of planters in this regard.

Table 1.—*Comparison in the ability of assist-feed and picker types of planters in spreading Corynebacterium sepedonicum.*

Replication	Treatment	Stand	Ring Rot Counts			Total Disease
			1	2	3	
1	Check-clean cut seed,	88	0	0	0	0
2	clean assist-feed planter.	114	0	0	0	0
1	Clean cut seed, infested	100	0	0	0	0
2	assist-feed planter.	98	0	0	0	0
1	Clean single drop seed, in-	93	0	0	0	0
2	fested assist-feed planter.	89	0	0	0	0
1	Clean cut seed, infested	88	12		23	35
2	picker planter.	77	12		19	31
1	Clean single drop seed,	96	0	0	7	7
2	infested picker planter.	86	12	4	37	53

Since the stain test was not used to determine whether any of the remaining hills were diseased, it should be apparent, from data presented later in this paper, that more of the hills could have been diseased, probably some of those planted with the assist-feed planter.

The value of using seed stock free from infection is clearly indicated in table 2. In this table can be found data showing how rapid the organism will spread by such means as the cutting knife and that

small amounts of infected tubers in seed are the source of much loss in the subsequent crop when such seed is used.

TABLE 2.—*Data showing rates of increase of ring rot in subsequent stand when seed contains* 1, 2, 3, 5, 7, 9, *and* 10 *per cent of infected tubers.*

Per Cent Infected Tubers in Seed	*Percent Diseased Hills in Subsequent Crop*		
	1944	22	1946
1	58.4		24*
2		56	8
3	72.4	54	38
5	88.9	74	44
7	84.0	72	50
9	84.3	1945	58
10			70

*This row was over-irrigated resulting in considerable water rot, which confused the picture.

In 1944 and 1945, the results obtained were based on field inspection and the stain test. In 1946, diagnosis for the presence of the causal organism was based entirely on the satin test.

To test the reliability of basing diagnosis on the presence of aerial symptoms only, the following data are presented to show that presence of aerial symptoms is not completely reliable as is shown in table 3.

TABLE 3.—*Inadequacy of the presence of aerial symptoms in diagnosing for the presence of ring rot in a stand of potatoes.*

	Symptom Group			
	No Visible Symptoms, Negative Stain	No Visible Symptoms, Positive Stain	Visible Symptoms, Negative Stain	Visible Symptoms, Positive Stain
No. of Hills	271	85	0	98

It is evident that the lack of aerial symptoms is not a sound criterion of the absence of ring rot in a stand of potatoes.

2. *Losses*

It has been stated that the presence of ring rot in a hill of potatoes does not mean a complete loss of marketable potatoes from the plant. In table 4 can be found data showing what reduction might be expected when the crop contains varying amounts of the disease.

DISCUSSION AND SUMMARY

It can be said that a picker type planter is a very capable instrument in disseminating the bacteria causing ring rot. If seed containing ring rot is planted with such an implement, it can be expected that considerable

TABLE 4.—*Data showing reduction in yield when stand of potatoes containing* 10, 20, 30, 40, 50, 60, 70, 80, 90, *and* 100 *per cent of hills are diseased with ring rot.*

1945				1946		
Per cent of Hills Infected	No. of Replications	Yield Pounds No. 1 Tubers	Per cent Decrease	No. of Replications	Yield Pounds No. 1 Tubers	Per cent Decrease
0	15	18.1	0	21	18.5	0
10	6	16.2	—10.5	13	17.1	—5.9
20	2	12.2	—32.6	3	18.3	—1.1
30				7	14.9	—19.5
40	3	13.0	—28.2	4	14.4	—22.2
50	1	10.9	—39.8	6	12.6	—31.9
60	6	11.3	—37.6	8	13.5	—27.0
70	4	11.8	—34.8	5	7.9	—57.3
80	5	7.9	—56.3	3	7.9	—57.3
90	2	6.8	—62.4	4	5.4	—70.9
100	4	4.1	—77.3	6	4.2	—77.3

increase of the disease in the crop will result. Under the conditions of the test herein recorded, an assist-feed type of planter did not spread the organism.

The highly infectious nature of the causal organism of ring rot is such that seed containing even a trace of infection should not be used. When it is realized that more than fifty per cent of a crop can become involved with the disease, when grown from seed which contains but one per cent of infection, it should be apparent to all growers that they should use nothing but completely clean seed.

It has been shown that ring rot may be present in a stand of potatoes despite the lack of aerial symptoms. It would therefore be impossible to estimate adequately the losses in a stand of potatoes based on percentages of hills showing aerial symptoms. Data are offered to show that it does not necessarily follow that the losses in production are in direct proportion to the percentages of the hills involved with the disease. A stand of potatoes involved one hundred per cent is still capable of producing approximately twenty-five per cent of what a stand, devoid of ring rot, will produce.

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THE RELATIONSHIP BETWEEN MATURITY, YIELD, COLOR AND COOKING QUALITY OF EARLY-CROP TRIUMPH POTATOES

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Growers of Triumph potatoes in the Gilcrest district of Colorado have observed that as the tubers mature the color tends to fade. They have also observed that once the vines are dead the tubers lose color, and this influences the length of time the tubers can be left in the soil. Bright red tubers sell more readily and at a somewhat higher price than poorly colored ones.

To obtain some information on the nature of the changes taking place, an exploratory experiment was started in 1946. Five samples of fifty tubers each were taken from as many different locations in a two-row strip through the field on the 25th of July, and on the 5th and 21st of August. At the time these samples were taken, the vines were removed from tubers in the adjacent row, but the tubers were left in the soil. It was planned to harvest the tubers which had had the tops removed on the 21st of August; however, they were not harvested until the 8th of September. By using this technique it was possible to get two sets of data, one giving the color and specific gravity (used as a criterion for cooking quality) at a certain stage of maturity; the other, the color and specific gravity of similar potatoes after they had lain in the soil for various lengths of time after removal of the vines. The results are given in table 1.

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[4]The writers wish to thank Mr. John Greenwalt for his assistance in conducting these tests.

The same kind of experiment was conducted on a different farm in 1947 to determine the changes in yield, color and specific gravity as the plant matures and the change in quality resulting from leaving tubers in the soil without vines. A split plot randomized block arrangement of five replications with 50 hills in each plot was used.

Both years the tops were removed by placing one foot on each side of the stems and pulling them loose from the tubers. This resulted in the removal of the entire stalk without pulling the tubers out of the soil.

Tuber color was determined with the disk colorimeter described by Sparks[1]. Specific gravity was calculated from the relationship of the weight of the tubers in air divided by the difference between the weight of the tubers in air and the weight of the tubers when immersed in water. Both color and specific gravity measurements were made within four days after the tubers were dug. In the meantime, they were stored at approximately 35° to 40° F. In 1946 the statistical comparisons were made by the "T" test, and in 1947 by analysis of variance. In 1947 soil, air and tuber temperatures were taken on a bright, sunny day with thermocouples. The results are shown in table 3. The soil was classified as Gilcrest sand.

Results

In 1946 the specific gravity of tubers with vines attached remained about the same between the 26th of July and the 21st of August as shown in table 1. Similar tubers when left in the soil without vines from the 26th of July until the 8th of September decreased in specific gravity from 1.0690 to 1.0619. The difference is significant at odds exceeding 19:1. Tubers from which the vines were removed the 26th of July were lower in specific gravity than those from which the vines were removed 10 days later, (August 5), by odds exceeding 19:1.

In 1946 tubers attached to green vines decreased in color from 74.7 per cent Eugenia red to 70.3 per cent Eugenia red between the 26th of July and the 21st of August. This difference in color is statistically significant at odds exceeding 99:1. Leaving similar tubers without vines in the soil from the 26th of July until the 8th of September resulted in the color fading from 74.7 per cent Eugenia red to 56.1 per cent Eugenia red, a color difference statistically significant at odds exceeding 19:1. Leaving tubers without vines in the soil from the 5th of August to the 8th of September resulted in the color fading from 70.8 per cent Eugenia red to 57.2 per cent Eugenia red. This color difference is statistically significant at odds exceeding 19:1 as you will note in table 1.

TABLE 1.—*The effect of maturity on color and specific gravity, and the effect of leaving tubers without vines in the soil on color and specific gravity,* 1946.

	Tubers Harvested			Tubers Left in Soil Without Vines[a]	
	July 26	Aug. 5	Aug. 21	July 26	Aug. 5
Condition of vines	Green	Leaves dying	Vine dead	Green	Leaves dying
Mean specific gravity	1.0696	1.0700	1.0698	1.0619	1.0652*
Mean color[b]	74.7	70.8**	70.3**	56.1*	57.2*

[a]Tubers designated as left in the soil were all harvested September 8. Tops were removed on the pre-harvest dates shown

[b]A color rating indicates the per cent Engenia red component, the remainder being light pinkish cinnamon (colors according to Ridgway's Color Standards).

*Significant at odds equal to or exceeding 19:1.

**Significant at odds equal to or exceeding 99:1.

There was no material difference in color between tubers from which the vines were removed on the 26th of July and those from which the vines were removed on the 5th of August (Table 1) when both lots were harvested on the 8th of September.

The 1947 results shown in table 2 indicate the same general trends with respect to color and specific gravity changes in relation to maturity as were found in 1946 for tubers harvested with vines attached.

The effects on color and specific gravity of leaving tubers in the soil without vines were considerably different from those of the 1946 experiment. In 1947 removing the vines and leaving the tubers in the soil failed to bring about color and specific gravity changes of the same magnitude as found in 1946, probably because of different growing conditions between years and between farms. In 1947 the tubers were considerably paler in color at the beginning of the test than they were in 1946. The yield (Table 2) was still increasing when the experiment was terminated on the 9th of August. The yield increase from the 19th to the 26th of July was highly significant; the increase between the 26th of July and the 2nd of August and from this date to the 9th of August did not quite attain significance at the 19:1 level. However, the increase in yield on the 9th of August exceeded that on the 26th of July by odds of 99:1.

DISCUSSION

Changes in tuber color accompanying maturity, though statistically significant, are of doubtful practical importance. A color difference no

TABLE 2.—*The effect of maturity on yield, color and specific gravity, and the effect of leaving tubers without vines in the soil on color and specific gravity*, 1947

Dates tops removed					July 19	July 26	Aug. 2	M. S. D.		
Dates harvested	July 19	July 26	Aug. 2	Aug. 9	Aug. 9	Aug. 9	Aug. 9	5 per cent	1 per cent	
Condition of vines	Green	Green	Leaves dying	Leaves dying	Green	Green	Leaves dying	5 per cent	1 per cent	
Mean yield, in 100 lb. sacks per acre	202	234	241	249				8.6	11.7	
Mean specific gravity	1.0730	1.0756	1.0733	1.0713	1.0729	1.0759	1.0743	.0019	.0025	
Mean color**	06.2	57.2	59.2	55.7	58.0	56.6	54.7	7.4	10.4	

*Tubers designated as left in the soil without vines were all harvested August 9; vines were removed on the pre-harvest dates shown.

**A color rating indicates the percentage of the Eugenia red component, the remainder being light pinkish cinnamon (color according to Ridgway's Color Standards).

TABLE 3.—*Tuber temperature on a bright, sunny day at Gilcrest, Colorado,* 1947

Time	Positions of Thermocouple*							
	1	2	3	4	5	6	7	8
2:05 p. m.	100	102	114	91	93	98	88	89
2:15 p. m.	92	103	112	92	92	98	86	88
2:45 p. m.	102	101	114	95	96	105	93	96
3:00 p. m.	103	101	111	97	95	103	93	95

*1. Air temperature in sun.
2. Air temperature in shade of a box.
3. Soil temperature in sun 1" below surface (soil dry).
4. Soil temperature in sun 1" below surface (soil moist).
5. Underside of a tuber 2" below surface (soil dry).
6. Top side of a tuber 2" below surface (soil dry).
7. Underside of a tuber 2" below surface (soil moist).
8. Top side of a tuber 2" below surface (soil moist).

greater than 10 per cent Eugenia red, though relatively easy to measure on the disc colorimeter, is difficult to detect without the aid of a standard.

However, it 1946 tubers that were left in the soil after the vines were detached lost enough color to make it a practical problem should the vines be removed or killed and the market "go dead" so that the tubers would have to remain in the soil devoid of vines for any length of time.

The specific gravity changes are also of doubtful practical importance. Early potatoes are seldom of good eating quality; and since the cooking quality, as measured by specific gravity, improves but little with maturity and may actually decrease, it appears evident that the proper time to harvest early potatoes should be determined on the basis of yield and market price.

It would appear from the results that "planting early and harvesting late" has little merit. There is but little increase in yield after the vines begin to die, and color as well as cooking quality, as measured by specific gravity, may actually be lost.

A potato tuber represents essentially the amount of carbohydrates not needed by the rest of the plant. Consequently when soil and tuber temperatures are high the rapid rate of respiration must be largely responsible for the low dry matter content of the tubers.

Summary and Conclusion

Yield, color and specific gravity changes in early crop Triumph potatoes were observed throughout the harvest seasons of 1946 and 1947 at Gilcrest, Colorado.

1. Yield in 1947 for tubers with vines continued to increase until the end of the experiment. The rate of increase was rapid at first and then rapidly declined.

2. Cooking quality (as measured by specific gravity) increased until hot weather set in and the tops began to die. Then it decreased slightly, but not to the point of being practically important.

3. Leaving Triumph tubers in the soil after the vines were removed did not materially affect the color or the specific gravity in 1947; however, color reduction of possibly practical importance was observed in 1946.

4. Triumph potatoes fade in color as they mature.

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SECTIONAL NOTES

Indiana

The potato situation in Indiana at the present time is very, very quiet. Several carloads of early varieties have been placed on the market and the purchasers have been those with a small acreage, buying as many as one to fifty and sometimes seventy-five sacks of potatoes, whereas the large grower is just marking time waiting to see what is going to happen. It appears that we will grow about 45,000 acres in potatoes this year, a drop from last year, and the growers with a larger acreage in central and northern Indiana will not plant until the end of April and the first part of May, providing the weather is agreeable.

We still find a good demand for potatoes, and judging from the comments I have heard the consumer will go back on a good potato diet if the situation ever clears up.—W. B. Ward

Missouri

The potato acreage in Jackson County will be approximately 2,350 acres in 1949. The 1948 acreage was 2,280 acres. Four hundred acres will be planted in the Orrick district (Ray County) where potato production is gradually becoming smaller with growers now planting alfalfa and other farm crops. The total acreage in this section (Jackson and Ray Counties) will be 2,750. Complete fertilizers are being used at planting time at the rate of 500 to 750 pounds per acre. The most popular analysis seems to be 8-8-8 with 10-6-4 the second choice. Most growers expect to side dress during the growing season with ammonium nitrate used at the rate of 200 to 250 pounds to the acre. Cobblers and Red Warbas are the varieties being planted. A few growers are trying a new variety in this section, known as the Dakota Chief. Only small plantings will be made of the Dakota Chief variety this spring.

Potato planting has been delayed and at this time probably not more than one-third of the acreage is in the ground. Excessive rains have kept the growers from our fields. A DDT and copper dust will be used again to control the Colorado potato beetle and various diseases. —Ben F. Vance

Nebraska

The shipping season for Nebraska potatoes is rapidly drawing to a close. Some table stock is still in farm storage, but mostly the poorer

lots. Dealers are finding it difficult to supply their brokers with sufficient supplies of U. S. No. 1's. In some cellars potatoes are sprouting badly. A number of the washer plants will close down this week.

Shipments of certified seed continued to be quite heavy throughout February, and the first week in March. Very little certified seed was moved during the month of January, due to the blizzard which covered the entire seed-producing area. Many growers feared that they would not be able to dispose of their seed. The seed market, however, held up two weeks later than usual, enabling them to dispose of most of their certified seed.

The weather in Nebraska is still more wintry than spring-like. Periods of wet snow or rain occur very frequently. Spring field work is being delayed by the mud. Growers in the central Nebraska commercial area of the state are unable to get into their fields to prepare them for planting. Planting usually commences in this area about the first of April.

Local movement of Foundation seed is taking place in the western late potato area at this time. During the past two weeks, the demand has exceeded the supply available. Growers have shown a great deal of interest in the new red variety, Progress. Only a limited supply of this seed is available, and this was spoken for early in the winter.

It is impossible at this time to estimate what acreage will be planted this year. Planting will not take place in western Nebraska until June. A reduction is proposed, and it seems quite likely that the acreage will be reduced somewhat again this year.—WARREN TRANK

NEW YORK

Our Marketing Agreement Committees are active and before the 1st of May proposed agreement for up-state New York will have been formulated. A series of meetings will be held later to acquaint our growers with the details.

The summer Field Day of the Empire State Potato Club will be held the first week in August, probably in Onondaga County near Syracuse. There is some talk of making this a two-day meeting and various committees are working on the details. We hope to have something definite for the next issue of the Potato Journal.

Certified seed is moving out rapidly despite prevalence of adverse conditions. We believe that as of April 1st the quantity of certified seed potatoes on hand is considerably less than the usual average for this date.

Growers, in general, are cooperating well with the acreage re-

duction program and seem to be quite well pleased with the one price feature. There are no indications that this arrangement will have a surplus, under normal harvesting conditions.

Our supply of table stock is exhausted. Market trends finished strong with prices about 25 cents above support. Shortage of local supplies as well as shortage of cars in Maine have tended to make demand exceed supply.—H. J. EVANS

SOUTH CAROLINA

Potatoes began to emerge the last week of February but frost during the first two weeks of March cut back a large part of the crop. Plantings near the ocean are flowering and are well ahead of schedule, whereas all other plantings are coming along on time. A few growers have reported that Sebagoes have been cut back and are not emerging in normal manner. An occasional plant has been lost, however, but in general the stands are good to excellent.

Although the rainfall has been below normal, weather conditions as a whole have been excellent for the progress of the crop. We anticipate some digging early in May but our general movement will not take place before the 15th.—W. C. BARNES

SUMMARY OF PAPERS PRESENTED AT THE POTATO CONFERENCE HELD AT THE EASTERN REGIONAL RESEARCH LABORATORY[1], OCT. 19-21, 1948

OBJECTIVES OF THE CONFERENCE

Dr. Wells pointed out that the conference was originally planned as a meeting of collaborators from the State Experiment Stations of the 16 Eastern states comprising the area served by the Eastern Regional Research Laboratory. In planning this meeting it was deemed advisable to invite representatives from other interested State Experiment Stations, as well as representatives from other Bureaus of the Department of Agriculture, potato grower organizations, and industry, for the purpose of reviewing and discussing current research on potato utilization in Federal, State, and industrial laboratories. Another object was to consider problems of the potato industry and to determine needed future research in the utilization field.—P. A. WELLS, Director, Eastern Regional Research Laboratory, U.S.D.A., Philadelphia 18, Pa.

[1]This conference was attended by leaders in the potato industry from all sections of the country. The papers presented cover a wide range of subjects of major importance to the industry. For this reason it is considered desirable to reprint the abstracts in this and the next several issues of the Journal.

Potato Outlets

The normal annual crop of potatoes in the United States is about 375 million bushels. A chart was shown which indicated the distribution of the crop for various uses. About 81 per cent (302 million bushels) is used for food, 5 per cent (26 million bushels) for seed, and 14 per cent (53 million bushels) for non-food purposes. Of the 302 million bushels used for food most of it goes for direct consumption (280 million bushels) and about 22 million bushels are consumed as processed food (chips, flour, dehydrated, canned, frozen, and peeled potatoes, and food starch). Manufacture of chips consumes the greatest bulk of processed potatoes (15 to 20 million bushels). About 4 million bushels were used in 1946 for dehydrated food products. About 20 million bushels were used for dehydration in 1943 and 1944 mostly for armed forces. Potato flour (15 to 20 million pounds) requires about 2 million bushels of potatoes. During the past year the production of potato flour was increased many times the normal amount (the goal about 400 million pounds). The flour is being sent to various European countries as a part of the emergency food program.

In the non-food uses livestock feeding is the largest outlet. About 25 million bushels of potatoes (as fresh, ensiled, and dehydrated) are used for this purpose. Starch production (for textile and paper sizes and dextrin, etc.) consumes 10 million bushels. During surplus years (and scarcity of corn) large amounts of potatoes were used for alcohol production (about 30 million bushels in 1946). Some butyl alcohol has been prepared from potatoes. Other potential industrial uses of potatoes were indicated, such as fermentation to lactic acid and other organic acids, acetone, butylene glycol, etc.—R. H. Treadway, Eastern Regional Research Laboratory, U.S.D.A., Philadelphia 18, Pa.

Problems of the Potato Industry

The following may be taken as basic and accurate premises:

(1) That potatoes are grown primarily as a food crop, and for use principally in the fresh form.

(2) That consumers apparently want, and should be given, clean, mature, smooth potatoes, acceptably sized, graded and packaged; and that they turn away from potatoes when these demands are not met.

(3) That sales for manufacture into processed form represent an outlet of lesser importance, though growing each year.

(4) That sales for non-food uses and for livestock feed are a form of safety valve for drawing off, first, the low grades, and then surpluses whenever supply exceeds demand.

(5) That since the average yield per acre in 1948 has reached an all-time high, acreage is the lowest in 67 years, and at the same time per capita consumption is down to an all-time low, production problems are at present less important than problems of distribution and use.

The importance of research in production, however, should not be minimized, and the relation of some distribution problems, such as those of consumer acceptance based on quality, to improvements in production methods should not be ignored. Rather it seems essential to emphasize that production research has been given many times the dollars and man-hours that have as yet gone into studies of marketing, distribution, and utilization.

Conclusion: The number one problem of the potato industry is to check the decline in consumption, which is both a per capita and an over-all decline. From this major problem stem many separate problems; possibly the facts brought out during the Potato Conference will be helpful in finding solutions to many of them.

Probably few in the potato business, including the growers, are completely happy with the government price support program. Originally planned to stimulate wartime food production, it accomplished its objective. It has eliminated the shortages and the black market of 1943, which the public has all too soon forgotten. The public has forgotten, too, that since the potato crop is perishable and has no carry-over, enormous wastes from overproduction have always been a common occurrence. In the days before price support, these losses were borne by the grower, or handler, or both. They caused many a bankruptcy—and nobody benefited.

The price support program has met criticism on two major points. One is based on the feeling that the public supports the program twice: once as taxpayers and again as consumers. The difficulty of finding good potatoes in the retail store also causes criticism.

The foregoing lends background to the concept that better utilization of our crop through applied research may be one of the best and surest means, though not the quickest, of improving the situation and pleasing the consumers.

To check declining demand, the principal problem in the potato field, the Department of Agriculture has begun potato marketing studies among both housewives and institutional users. The results obtained thus far point clearly to the necessity of offering the consumer a better product. The customer wants clean, properly graded, and attractively packaged potatoes. More information is needed on sizes, colors, and

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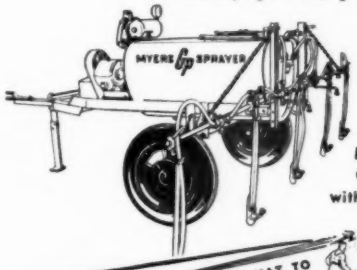

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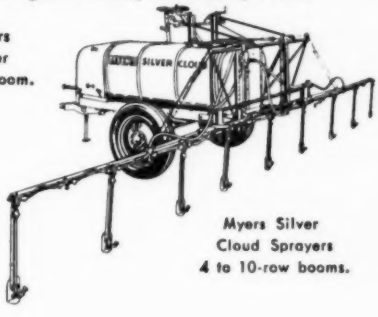

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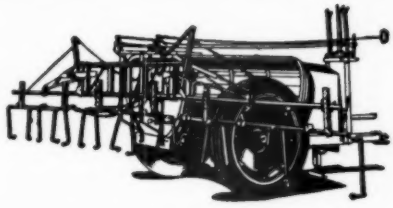
the cooking quality of potatoes for specific uses, such as french frying, mashing or baking.

Probably production control alone can never achieve a satisfactory balance between potato supply and demand. Goals set too low may cause under-supply. It seems safer to *grow enough, then sell the best, and process the rest.* To accomplish this requires the joint efforts of both growers and research men. The industry must find ways, through marketing agreements and other means, of withholding its poorer potatoes from retail sale. The Laboratory must develop new or improved ways of transforming potatoes into useful products. Both the industry and the government, but with emphasis on the former, should attempt to make diversion outlets self-supporting. If this is economically impossible, the cost burden, at least partially, should be distributed over the better portion of the crop and less upon the taxpayer. In the last analysis, research should play an important role in determining future non-food uses of potatoes.—KRIS BEMIS, United Fresh Fruit & Vegetable Association, Washington 9, D. C.

METHODS OF HANDLING POTATO SURPLUSES

The problem of utilizing surplus potatoes was relatively easy before the last war and during the war. In 1934, prices were supported by purchase of potatoes for relief feeding. In 1937, about 6 million bushels of potatoes were diverted to starch and 2 million bushels to livestock feeding. The situation in 1940 was rather similar to that of 1937, with 8 million bushels going into each of the livestock feeding and starch outlets. In 1942, the first year under the Steagall amendment, acreage was reduced and war needs kept the surplus problem at a minimum. A large outlet in dehydrated potatoes for the armed forces and Lend-Lease existed throughout the war.

In 1943. 23.4 million bushels of potatoes were in surplus, of which 7 million bushels were diverted to starch and 9 million bushels to livestock feed. The surplus was slight in 1944, amounting to only 3.6 million bushels. In 1945, the surplus amounted to 23 million bushels, of which 8 million went for export, 6 million to starch, and 3 million to alcohol. The largest surplus to date, 108.5 million bushels, occurred in 1946. Due to the grain shortage, 30 million bushels of potatoes were diverted to alcoholic fermentation during that year; 20 million bushels went into livestock feeding, 11 million bushels were exported, and 9 million bushels went to the starch factories. A record of 34 million bushels of potatoes, however, was lost during 1946 by the necessity of dumping.



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The year 1947, with a surplus of 35 million bushels, was characterized by the development of an increased potato flour outlet. The export trade was the greatest outlet, 12 million bushels of the 1947 surplus, with alcohol consuming 7 million bushels, starch consuming 5 million bushels, and flour and direct distribution (school lunches, public institutions, etc.) consuming 4 million bushels each.

The surplus for 1948 is now (Oct. 18, 1948) estimated at 65 to 75 million bushels. Most of the surplus, up to the end of September has gone into ethyl and butyl alcohol. The Government is trying to procure 440 million pounds of potato flour for the Army. During the past 3 months, 50 million pounds of potato flour have been delivered to the Army; this is about 3 times the former annual capacity.

Prospects for future export of potatoes are dim. The flour and alcohol outlets will probably not continue at their present high levels. This leaves only starch and livestock feeding as major outlets. In most of the outlets, the amount which the Government recovers does not equal the costs of freight and storage. The principal objective of research work should be to develop methods of utilizing locally low-grade and surplus potatoes so that no long distance transportation is involved. Field, open-air dehydration may be the answer to this, thus producing a stable form of the potato for industrial use.—A. E. Mercker, Production and Marketing Administration, U. S. D. A., Washington, D. C.

Problems in the Manufacture and Uses of Potato Starch

The major problem confronting the potato starch industry is the lack of a uniform and continuous supply of potatoes for processing. The human consumption of potatoes is relatively constant and thus small crops bring higher prices than larger crops. Even though acreage remains fairly constant, there is a considerable variation in yield per acre and therefore the size of the crops and the prices received for them vary greatly. An increase of only 2 to 4 per cent above average production often seriously depresses prices.

In years when growing conditions are favorable enough to produce a surplus crop, or market conditions outside the country are unfavorable, or blight hits the crop, the starch factories have ample supplies and profit, and the farmer takes a licking.

In short years the reverse is true. With a constant demand and short supply prices rise. Lower grades find a waiting market at prices higher than industry can pay for potatoes. The lack of sufficient potatoes to supply the Maine factories, where the potential capacity is 25,000 tons of starch, is best illustrated by the following estimated yearly pro-

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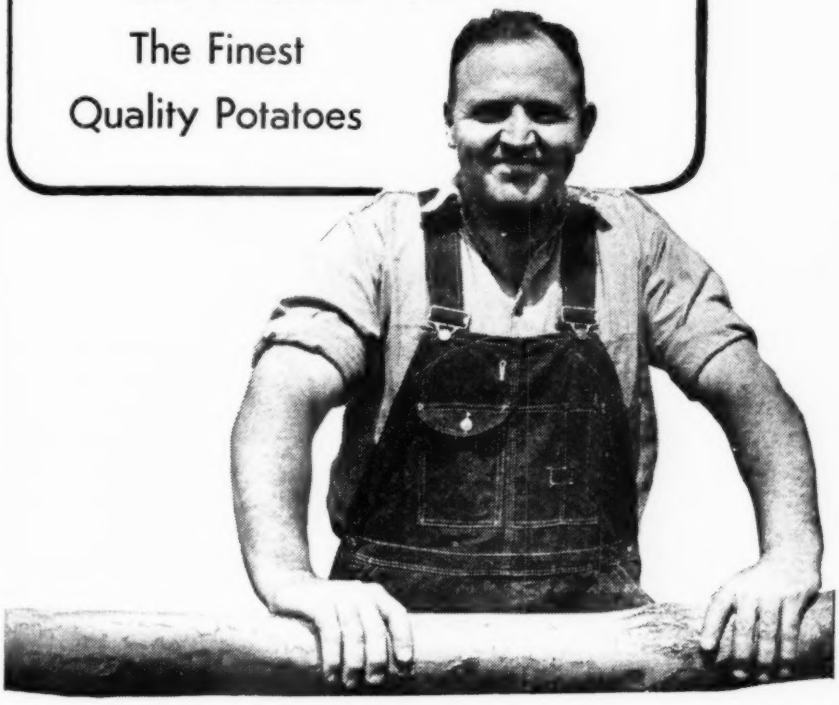

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duction figures. It will be noted that in most cases the yearly production was well below the total productive capacity.

1938	11,000 Tons
1939	9,000 "
1940	17,000 "
1941	15,000 "
1942	12,000 "
1943	24,000 "
1944	20,000 "
1945	12,000 "
1946	22,000 "
1947	17,000 "

Up until the last eight or ten years there was a sharp decline in the number of factories and lack of incentives for modernization due to fluctuation in raw material supply. Since that time the supply of potatoes although lacking anything ideal in its continuity, has been more stable. This is primarily due to diversion of surplus raw material to starch purposes. The results are the extensive modernization of the majority of the existing plants in Maine, the construction of several modern continuous plants and the establishment of a modern potato starch industry in Idaho which produces about 25,000 tons of starch per year.

Still further stabilization of the sources of raw material would attract additional capital in the modernization and replacement of existing plants and it would be an inducement to properly trained personnel to participate in this field.

We feel the primary and most extensive need is an all-out program of education of the importance of our industry in the overall production and marketing of this important agricultural commodity. In Maine, we are becoming slowly cognizant of this fact and have banded together in a non-profit trade organization, The Maine Institute of Potato Starch Manufacturers is to further our efforts in correcting this condition and to solve our many other problems.

Secondly, we feel that closer cooperation between the different segments of industry, such as production and sales with the production, marketing and research divisions of the United States Department of Agriculture could materially further the stabilization of our industry.

Only by combining our research efforts with the efforts of the Bureau of Agricultural and Industrial Chemistry can a far reaching program of development be achieved.

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Our basic problems in the uses of starch are mostly confined to efforts in attracting new users. We have a potential production of 50,000 tons of potato starch in the United States and the present users can take between 25,000 and 30,000 tons per year. This leaves about 20,000 tons for new potential uses.

According to Dr. Brautlecht the present uses of potato starch are distributed about as follows:

Textile industry	40 per cent
Foods	20 "
Confectionery	5 "
Paper industry	10 "
Dextrine	15 "
Miscellaneous	10 "

A considerable amount of starch has been exported in the last few years. However, the future of this market is uncertain.

Further utilization by the textile industry will depend largely on improvement in quality of our product, its constant availability and the price relation between it and other competitive starches.

Our largest potential markets are in the paper and food fields. In the paper field, there are today roughly 100,000 tons of corn starch used. Our continued entrance into that field will largely depend on, again, competitive prices of other starches and our ability to furnish stability of both price and supply. This also applies to the food field.

We must endeavor to determine the relative merits of potato starch in comparison to other starches in the various fields.

A standard of grades should be formulated to eliminate confusion on the part of the manufacturer and user. Our Institute has started an investigation of the present grades of potato starch and find that they are almost wholly non-existent. These starch grades as far as practicable should be uniform to the extent that the relative merits of each manufacturer can be compared to other potato starch manufacturers and to other type starches.

Further efforts in research in conjunction with this laboratory in new uses should be continued.

The disposal of potato starch factory wastes will soon require our efforts. For the disposal of potato "pomace" or pulp from the factories, our Institute is now in the process of creating a pilot plant at Mapleton, Maine, with the hope that the process, with the help of this laboratory and the staff of the Extension Service of the University of Maine will be a success. Work has also been done in the ultimate use of this end

POTASH and POTATOES

Potatoes are greedy feeders on potash. They remove more of this plant food from the soil than nitrogen and phosphoric acid combined. For a good yield of No. 1's your soil and fertilizer should supply at least 200 lbs. of available potash (actual K_2O) per acre. Consult your official agricultural adviser or experiment station about the fertility of your soil. Write us for additional information and literature on how to fertilize your crops.

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product as a livestock feed at the Experiment Station of the University of Maine.

In conclusion I would like to state that the producers and handlers are beginning to stabilize their industry by marketing a superior product. This is exemplified by the acceptance in the various potato areas of marketing agreements. The elimination of lower grades of potatoes from commercial markets can be of great benefit to stabilizing the potato industry. With sound and economical disposal plans an agency should be able to stand on its own feet as a disposal outlet, and be in a position to make the greatest return to the producer of potatoes for his product.—J. H. Page, Maine Institute of Potato Starch Manufacturers, Caribou, Maine.

Factors Influencing the Quality of Potato Starch

A most important property of all commercial starches is their ability to swell in hot water to form viscous liquids, or pastes. This property is utilized whenever starch is used as a thickening or gelling agent, a coating or sizing material, or an adhesive. Swelling in a limited amount of water is a major reaction when starchy foods are cooked, or dehydrated by heat. Among the commercial starches potato starch swells the most, giving the most viscous and unstable pastes, and is also the most variable.

Potato starch is easily prepared about 100 per cent pure. Its 0.3 per cent of inorganic constituents (ash) should not be regarded as an impurity since they are chemically bound to the starch substance. The ash is often neglected or insufficiently considered, and is the source of much of the reported variability of potato starch. Potato starch differs from the other starches of commerce in that it contains phosphoric acid esterified with the carbohydrate. The phosphoric acid is combined only with the amylopectin fraction—one acid group to approximately 300 glucose units—and it ionizes similarly to ordinary phosphoric acid. In the potato it is about three-fourths converted to the potassium salt. The potassium is readily displaced by other metal ions, with particular ease by the calcium and magnesium of hard water. Potato starch is thus a water softener of low exchange capacity.

The calcium (hard water) starch may be regenerated into the potassium starch by brief soaking in a solution of a potassium salt, followed by washing out excess salt with pure water. The viscosity of the potassium starch pasted in pure water is very much higher than that of the calcium starch. A few parts per million of any electrolyte added before or after pasting reduces the viscosity of the pastes to almost the

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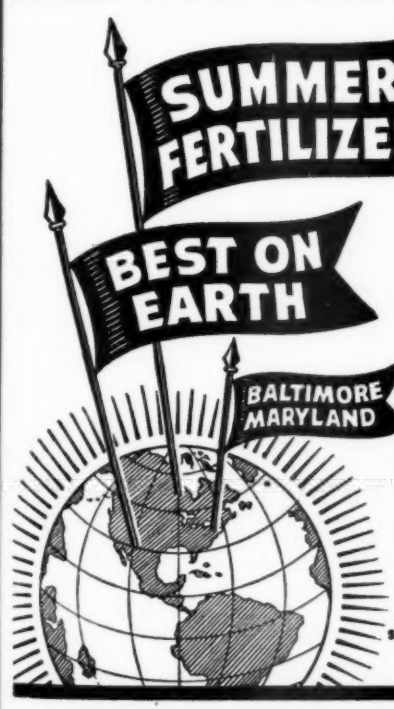

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same very low value. Paste viscosity shows a sharp maximum at pH 8 even when adjustment of pH is made on cool pastes so that hydrolysis is avoided. The high viscosity of potassium starch pastes is due largely to the enormously swollen granules. These are thin, and when broken by stirring or dissolving in the pasting water, the viscosity drops correspondingly.

Heating potato starch in an excess of water at a relatively low temperature, or in water vapor near 100° C., changes the granule structure so that it becomes much like a cereal starch. Swelling is less, paste viscosity is lower and more stable, and the tackiness and translucency are less.

Small potato starch granules contain slightly more phosphoric acid than do large granules. Correspondingly, the small granules show the higher swelling, when the starch phosphoric acid is combined with sodium or potassium. When combined with calcium, the swelling of granules of all sizes is substantially equal.

Commercial potato starch, stored with the normal 15 per cent moisture at room temperature, shows no detrioration over at least a two-year period. It is still unsettled whether the regenerated starches are similarly stable.

An experiment with Green Mountain potatoes showed that starch quality did not change during storage of the potatoes for periods up to nine months at temperatures of 30°, 42° and 50° F. On storage, the starch loss by respiration or reversion to sugars may be 25 per cent or more. Conceivably this would alter the granule structure of the molecular properties enough to change the swelling power. However, the potassium starch extracted from the stored potatoes using distilled water gave nearly constant paste viscosity for the whole storage period.—G. C. NUTTING, Eastern Regional Research Laboratory, U. S. D. A., Philadelphia 18, Pa.

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